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New Orleans, Louisiana

TAGGING MORTALITY AND TAG SHEDDING OF
JUVENILE GULF MENHADEN, *Brevoortia patronus*

by
James Byars

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by
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ABSTRACT

This study measured the differences in tag shedding and tagging mortality rates between two different taggers, two tag sizes, and among five 20 mm size classes of juvenile Gulf menhaden ranging in size from 50 mm to 150 mm.

No significant differences ($p \leq 0.05$) were detected between taggers except for menhaden 50-67 mm in the laboratory experiment. No significant differences were detected between tag sizes for fish of the same size. There were significant differences in tag losses among the size classes of menhaden tested in the field experiment where 50-69 mm fish experienced almost total mortality. A successful system for holding menhaden for laboratory experiments is also described.

INTRODUCTION

Gulf menhaden, *Brevoortia patronus,* make up the largest fishery in Louisiana by weight and are second only to shrimp in dollar value. During the 1978 fishing season, 684,354, 860 kilograms (kg) of menhaden worth $64,504,956.00 were landed at Louisiana ports (National Marine Fisheries Service No. 7725, Louisiana Landings, December 1978). For the past 15 years NMFS has been engaged in a program of tagging Gulf menhaden to study movements and exploitation rates. Juvenile menhaden are tagged with internal ferro-magnetic tags in the estuaries and the tags are recovered from magnets installed in the menhaden reduction plants. One major drawback in using tag returns for fish population analysis has been the lack of information concerning tag losses through shedding and tagging mortality; therefore, this project was conducted to investigate these tag losses.

The primary objective of this project was to determine the rate of tag loss as a function of the size of juvenile Gulf menhaden tagged. Other objectives were to determine if the differences in tag losses for different taggers is great enough to require that taggers be treated as fixed factors in tagging study analyses, and to test the difference in tag losses between two tag sizes. This information will be helpful in on-going tagging projects being conducted by NMFS to study recruitment of menhaden into the fishery and to assess the size of the Gulf menhaden population.

MATERIAL AND METHODS

This study was initiated in May of 1978 and concluded in October 1979. It was conducted by personnel from the Louisiana Department of Wildlife and Fisheries' Coastal and Marine Resources Division at the Marine Research Laboratory on Grand Terre Island. Figure 1 provides a map showing the location of the Marine Laboratory and the experimental ponds used for this experiment. The study consisted of two phases, a laboratory experiment and a field experiment. Menhaden for both experiments were collected from a small canal adjacent to the Marine Laboratory, using a 30.48 m bag seine (1.22 m deep with 6.35 mm bar mesh) and transported by boat in a 239.5 liter rectangular nylon tank. Vigorous aeration was maintained throughout the trip.

Experiment 1.—The laboratory experiment was conducted in an enclosed building to provide a disturbance-free environment. The fish were held in a circular fiberglass tank which was 2 m in diameter by 0.80 m deep (Figure 2). A central drain (38.1 mm in diameter) fitted with a 0.7 m long PVC standpipe served to maintain a constant water level. An inverted standpipe, 101.6 mm × 0.9 m long with two 38.1 mm holes drilled near the bottom end and covered with 6.35 mm hardware cloth, was placed around the standpipe. This arrangement of a standpipe within a larger pipe allowed all overflow water to be drawn from the bottom of the tank. A continuous flow of water (2000 liters per hour) was supplied to the tank with a 1/3 hp electric centrifugal pump through two 12.7 mm ID PVC water supply pipes. One supply pipe was fixed across the top of the tank and the other across the tank bottom. Holes 3.2 mm in diameter were drilled in both pipes so as to direct streams of water in a clockwise direction around the tank. The jetting action of the streams of water and the sweeping action of the clockwise current in the tank kept particulate matter from settling on the bottom. Uneaten food and other organics were discharged with the overflow water through the bottom of the inverted standpipe and over the inner standpipe.

Gulf menhaden were acclimated in the tank for 21 days, during which time they were fed pulverized commercial fish food daily, and all dead fish were removed from the tank twice daily. The fish were not fed for the three days prior to tagging in an attempt to insure that the intestines were uniformly flaccid. Kroger (1972) reported that in "starved fish, tags evidently slipped past the flaccid intestines without damaging them."

After the three-week acclimation period all fish were removed from the tank, the fork length to the nearest mm was recorded and separated into one of the following size classes: 50-69-size class 1; 70-89-size class 2; 90-109-size class 3; 110-129-size class 4; and 130 and larger-size class 5. Each size class was placed in a separate 239.5 liter aerated holding tank. Every third fish in each size class was fin-clipped on the ventral lobe of the caudal fin to designate fish to be used as controls; all other fish were fin-clipped on the dorsal lobe of the caudal fin to designate fish to be tagged. When all fish had been removed from the circular tank, it was drained, cleaned, and refilled at which time tagging was initiated.

Two taggers were used, each tagging one-half of the non-control fish in each size class. Tagger A was

Figure 1. Location of the Marine Research Laboratory of Grand Terre Island

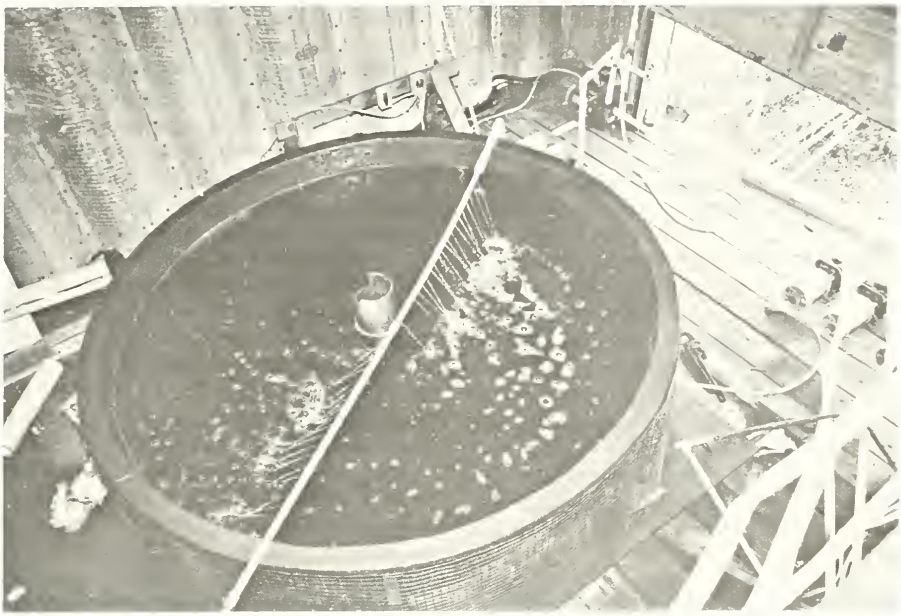

Figure 2. Two meter Dia. Tank showing stand pipe, inverted stand pipe and water supply pipes. Inverted stand pipe out at position.

a very experienced tagger from NMFS at Beaufort, North Carolina, and tagger B was from Louisiana's Marine Research Laboratory and had comparatively little experience at tagging menhaden. Two tag sizes were used (adult tags-14.0 mm × 3.0 mm × 0.5 mm and juvenile tags-7.0 mm × 2.5 mm ×0.4 mm). Both tags were made of ferro-magnetic stainless steel. The tags were inserted posteriorly from just below the origin of the pectoral fin, using a Bergen-Nautick tagging gun as described by Pristas and Willis (1973)*.

When the circular tank was refilled, the fish were then removed from the holding tanks, a few at a time, and placed in a small plastic pan of water in front of each tagger. If the ventral caudal lobe was clipped, the fish was held for a few seconds and released into the circular tank as controls. If the dorsal lobe of the caudal fin was clipped, the fish was tagged and released into the circular tank. The largest size class was tagged first, and each successive smaller size class tagged in order. All fish in a size class were tagged before starting the next size class. Each tagger tagged one-half of the non-control fish in size classes 1 and 2, and one-fourth of the non-control fish in size classes 3, 4, and 5 with juvenile tags, and one-fourth of the non-control fish in size classes 3, 4, and 5 with adult tags. Each tagger used a different series of tags for each size class. The tag series was recorded for each size group. Upon completion of tagging, all remaining tags were counted to insure that the number of tags used was the same as the number of fish recorded as tagged.

Feeding was resumed twice daily after tagging. At each feeding, all dead fish were removed from the tank, measured and dissected to recover the tags. The tank bottom was swept with a magnet twice daily to recover shed tags. At the end of the 21-day experiment, the tank was drained to collect the fish which were then preserved by freezing until they could be measured and dissected to recover the tags.

Experiment 2.—The field experiment was conducted at the Marine Research Laboratory in 0.10 hectare experimental ponds (as described by Broom 1968, and Neal and Latapie 1972). The ponds were fertilized with 63.5 kg of catfish pellets. Menhaden were placed in the pond and acclimated for one week prior to beginning the experiment. This experiment was designed to be similar to conditions normally encountered by tagging crews, and the techniques used were the same as those normally used for menhaden tagging (Kroger, et al.

*This does not imply endorsement by NMFS or Louisiana Department of Wildlife and Fisheries.

1971, Kroger and Dryfoos 1972, Kroger and Guthrie 1973). The fish were collected from the pond using a 30.48 m-long bag seine, 1.22 m deep, with 6.35 mm bar mesh and placed in a 0.61 m × 1.22 m holding net 0.61 m deep. Three hundred fifty fish were removed from the holding net randomly and preserved by freezing for later measurement to obtain a length frequency distribution of the fish in the experiment. The fish to be tagged were removed from the holding net a few at a time to put into small plastic pans of water in front of each tagger. These fish were then tagged and transported in a 239.5 liter tank to the adjacent 0.10 hectare fertilized pond. Each tagger tagged 500 fish with juvenile tags and recorded the tag numbers. The fish were fed daily, and the water level was maintained by pumping as needed. At the end of the 21-day experiment, all fish remaining in the pond were harvested and preserved by freezing until they could be measured and dissected to recover the tags.

After all fish from both experiments had been harvested, the fish were thawed, measured, and the tags, if present, were recovered. Due to the small number of fish in size classes 4 and 5, these were combined and treated as one class (110 mm+).

The number of menhaden surviving and dying (shed tags were considered dead fish) in the experiment were summarized for the controls and for each of the treatment combinations of tag size, size class of fish, and tagger. Survival of fish was treated as a linear model of treatment combinations. The G.S.K. method (Grizzle, et al. 1969) was used to test for differences in survival between treatment combinations using a computer program called FUNCAT, available in SAS (SAS Institute, Inc. 1979).

A level of probability $p \leq 0.05$ was selected as significant, however actual probabilities for the various tests are given in the table where appropriate.

RESULTS AND DISCUSSION

In the laboratory experiment, tag losses ranged from 35.3% for fish tagged with adult tags to 30.0% for fish tagged with juvenile tags; 19.3% of the fish used as controls died. Tag shedding accounted for 26.7% of tag losses for fish tagged with adult tags and 37.5% for fish tagged with juvenile tags (Table 1). Kroger and Dryfoos (1972) reported that death was the most important factor in tag losses for fish tagged with adult tags and shedding was the most important factor in tag losses for fish tagged with juvenile tags.

Figure 3 presents a graph of numbers of deaths of fish for each day of the experiment. Tagged fish and controls were pooled for this graph. Tagging mortality was highest at the beginning of the experiment and decreased sharply approaching zero by day 12. Unfortunately, some shed tags disappeared from the tank through the standpipe discharge; therefore, a graph of tag shedding could not be produced. Ten percent of all fish in the experiment were unaccounted for when daily recoveries of dead fish were added to the number of fish surviving the experiment. These losses were probably caused by wild animals or a ferral cat fishing dead menhaden from the surface. For this experiment, all fish unaccounted for are considered tagging mortalities and are assumed to have died at the same rate at which they were recovered.

Statistical analysis of the tag losses for fish tagged with juvenile tags yielded the following results: there were no significant difference in tag losses between the size classes of fish tested; there were significant differences in survival rates when the two taggers and control fish were tested (Table 2). This difference is located in the difference in mortality rates between the inexperienced tagger (tagger B) and the controls, and is caused primarily by the higher mortality rates of size class 1 fish tagged by tagger B (Table 3). Despite this higher mortality rate for small fish, tagger B achieved a slightly lower overall mortality rate than did tagger A.

Statistical analysis of tag losses for fish tagged with adult tags yielded the following results: there were no significant differences in tag loss between taggers; there were, however, significant differences in mortality rates between the two size classes of fish tagged (Table 4). Size class 3 had a much higher mortality rate than did size class 4 (Table 1).

When the mortality rates for menhaden tagged with adult tags were analyzed together with menhaden of the same size tagged with juvenile tags, there were no significant differences between taggers A and B and no significant differences between the two tag sizes. There was, however, a significant difference between size classes. Class 3 had a higher mortality rate than did size class 4, and mortality rates for tagged fish were significantly higher than for the controls (Table 5).

In the field experiment total tag loss was 64% with tag shedding accounting for 21.8% of these losses. Results from the field experiment closely paralleled results from the laboratory experiment in that there were no significant differences in mortality rates between the two taggers. However,

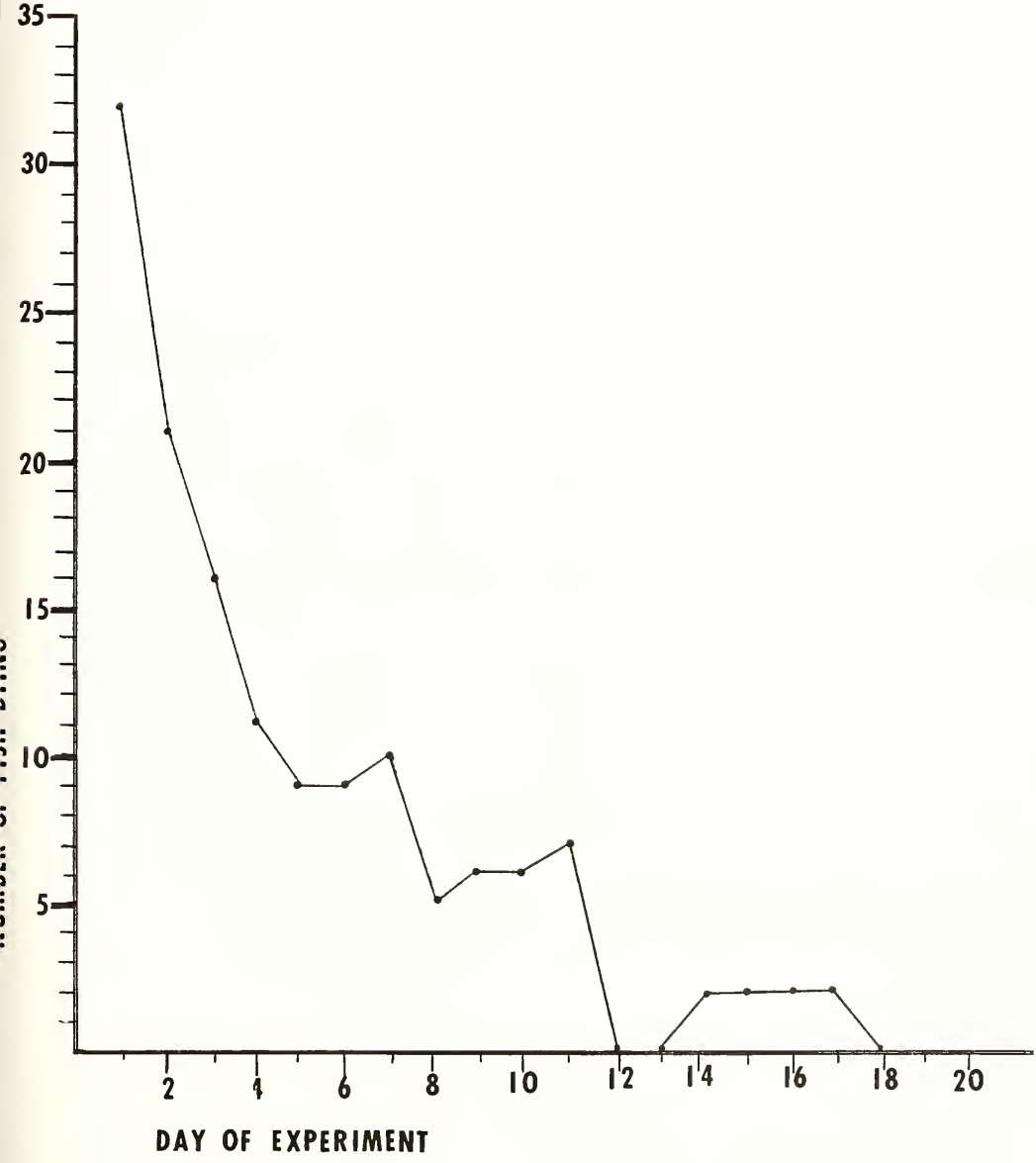

Figure 3. Number of fish dying for each day of the experiment.

Table 1.

TAG SHEDDING AND MORTALITY RATES OF MENHADEN IN LABORATORY EXPERIMENT

Size	Class (mm)	No. Fish in Experiment	No. Dead	No. Shed	Total	% Loss
JUVENILE TAGS						
1	50-69	62	11	12	23	37.1
2	70-89	120	17	14	31	25.8
3	90-109	50	14	3	17	34.0
4	110+	35	6	3	9	25.7
	TOTALS		48	32	80	30.0
ADULT TAGS						
3	90-109	49	18	6	24	49.0
4	110+		4	2	6	16.7
	TOTALS		22	8	30	35.3
CONTROLS						
1	50-69	31			5	16.1
2	70-89	60			10	16.7
3	90-109	52			13	25.0
4	110+	33			6	18.2
	TOTALS	176			34	19.3

Table 2.

CHI-SQUARE ANALYSIS OF JUVENILE TAG LOSSES IN LABORATORY EXPERIMENT

Source	DF	Chi-square	Probability
Size Class	3	3.24	0.36
Tagger and Control	2	7.65	0.02*
Size Class × Tagger Interaction	6	5.90	0.43

*significant at $p \leqslant 0.05$

Table 3.

TOTAL TAGGING LOSS IN PERCENT OF MENHADEN TAGGED IN THE LABORATORY WITH JUVENILE AND ADULT TAGS
(total number of fish tagged are shown in parentheses)

Laboratory Experiment—Juvenile Tags

Size	Class (mm)	Tagger A	Tagger B	Total	Control (%)
1	50-69	29.0 (31)	45.2 (31)	37.1	16.1 (31)
2	70-89	30.0 (60)	21.7 (60)	25.8	16.1 (60)
3	90-109	44.0 (25)	24.0 (25)	34.0	25.0 (52)
4	110+	27.8 (18)	23.5 (17)	25.8	18.2 (33)
	TOTALS			29.97	19.3

Laboratory Experiment—Adult Tags

Size	Class (mm)	Tagger A	Tagger B	Total	Control (%)
3	90-109	46.1 (26)	52.1 (23)	49.1	25.0 (52)
4	110+	16.7 (18)	16.7 (18)	16.7	18.2 (33)
	TOTALS			35.24	22.4

Field Experiment—Juvenile Tags

Size	Class (mm)	Tagger A	Tagger B	Total
1	50-69	95.8 (95)	95.8 (95)	95.8
2	70-89	55.2 (230)	60.0 (230)	57.6
3	90-109	55.2 (145)	62.1 (145)	58.7
4	110+	33.3 (30)	50.0 (30)	41.7
	TOTALS			62.5

Table 4

CHI-SQUARE ANALYSIS OF ADULT TAG LOSSES IN LABORATORY EXPERIMENT

Source	DF	Chi-square	Probability
Size Class	1	11.73	0.0006*
Taggers and Control	2	3.08	0.2145
Size Class × Tagger Interaction	2	3.93	01399

*significant at $p \leqslant 0.05$

Table 5

CHI-SQUARE ANALYSIS OF TAG LOSSES FOR SIZE CLASSES 3 AND 4 USING BOTH JUVENILE AND ADULT TAGS

Source	DF	Chi-square	Probability
Size Class 3 Versus 4	1	8.93	0.0028*
Juvenile Versus Adult Tags	1	0.70	0.6513
Tagger A Versus Tagger B	1	0.44	0.5049
Tagged Fish Versus Control	2	6.36	0.0415*
Tagger + Size Class Interaction	1	0.13	0.7218

*significant at $p \leqslant 0.05$

Table 6

CHI-SQUARE ANALYSIS OF TAG LOSSES OF MENHADEN IN THE FIELD EXPERIMENT

Effects	DF	Chi-square	Probability
Fish Size	3	278.94	0.0001*
Tagger	1	0.11	0.7369
Fish Size × Tagger	3	3.74	0.2907

*signfificnt at $p \leqslant 0.05$

Table 7

MORTALITY RATES OF MENHADEN IN THE FIELD EXPERIMENT BY SIZE CLASS

Size		No. Fish in Experiment	Total Tag Loss (%)
1	50-69 mm	190	95.8
2	70-89 mm	460	57.6
3	90-109 mm	290	58.6
4	110+	60	58.3

there was significant differences between size classes of fish tested (Table 6). Size class 1 showed the highest mortality while size classes 2, 3, and 4 were nearly equal (Table 7).

Mortality rates for menhaden tagged in the field experiment were much higher than were those for menhaden tagged in the laboratory experiment. Part of this increased mortality may have been due to the tagging speed and the extra care given to the menhaden in the laboratory experiment. Kroger, Sekavec and Leir (1974) suggested that the higher tagging speed used to inject tags under field conditions caused more tag loss than did the slower tagging speeds used under experimental conditions. Additionally some increased mortality could have been caused by weather conditions encountered while the fish were being tagged and while they were being harvested. Immediately after tagging in the field experiment began, a severe thunderstorm struck which may have caused the taggers to be nervous and, possibly, affected tagging mortality.

A hurricane evacuation was ordered after harvest had begun but before the harvest could be completed, some fish were left in the pond during the three day evacuation. Because the pond had been lowered almost to the catch basin, these fish were more exposed to predation from birds in the area.

When the menhaden from both experiments were being dissected to recover the tags at the conclusion of the experiments, some fish were observed to have lesions and considerable erosion of tissue associated with the tag. This investigator feels that some additional tags would have been lost through shedding had the experiment lasted longer; however, because this was noticed after some of the fish had been dissected and discarded, no attempt was made to separate these fish from other fish surviving at the end of the experiment. The possibility of shedding of these tags may indicate that the three weeks allowed for tag shedding in this experiment were not sufficient.

CONCLUSIONS

1. The difference in mortality rates between the taggers is not great enough to treat taggers as fixed factors in tagging study analysis except for menhaden under 70 mm fork length.

2. Menhaden under 70 mm fork length should not be tagged or they should be treated separately in any tagging study.

3. There is no significant differences $p \leqslant 0.05$ in mortality rates between menhaden tagged with adult tags and menhaden of the same size tagged with juvenile tags.

4. Menhaden 110 mm fork length and larger had significantly lower mortality rates than did menhaden 90-109 mm fork length when tagged with adult tags.

5. Mortality rates for menhaden in the field experiment were considerably higher (60%) than were the mortality rates for the laboratory experiment (30%).

6. Tag shedding accounted for approximately one-fourth of all tag losses.

7. All tag shedding may not have ceased at the termination of the experiment.

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